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Letter
Circular

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AQUARIUM CEMENT

It requires no argument to prove that a leaky aquarium is a nuisance to its owner and may be disastrous to its inmates. This Letter Circular tells how to make and use aquarium cement, and gives more detailed instructions than would be possible in an ordinary letter.

It is assumed that the reader is to make his own aquarium, frame and all. This accounts for the paragraphs concerning the strength necessary. The primary object of the cement is not to hold the aquarium together, but to prevent leakage. It can be taken for granted that the manufacturer of aquaria knows enough not to put flimsy ones upon the market.

The design and construction of the metal framework of the aquarium must reflect the ingenuity and skill of the maker, but if the composition of the cement were left entirely to him, without any helpful suggestions, he might be at a loss to know where to start. The three cements for which formulas are given are known to be good, and they will be entirely satisfactory if properly made and used.

It will be assumed that the frame of the aquarium is made of metal. Although it may rest on a wooden base, the construction must be such that the cement will not come into contact with the wood. If this should occur, the wood will tend to draw the oil out of the cement, which will then be slightly porous. The result may be that moisture will ooze through to the wood and cause it to warp, and thus place an undue strain upon the whole aquarium and perhaps ruin it.

If an aquarium filled with water is picked up and moved to another place, there is a chance of starting leaks, because the stresses upon the frame are not distributed as evenly, nor in the same way, as when the aquarium is resting upon a flat surface. If the frame is of very rigid construction, it may be lifted, but even then it is safer to dip - not pour - out most of the water beforehand. For a large aquarium, a cheap "kitchen" table with casters is a convenient support, which can be moved with little effort.

The frame should be so strong that the pressure of the water will not be able to spread the sides apart. Strength without a heavy appearance of the frame is most easily secured by having a strong metal trim around the top. This will not only hold the sides together, but it will also shield the upper edges of the glass panes, which would otherwise have to be ground smooth. If left rough they would be unsightly and dangerous. They would be pretty sure to cut the hands and chins of visiting small children, who always seize the top edge of the aquarium and look in over it.

The pressure against the sides is not a matter of theory, but something very real. If an aquarium which measures 18 by 24 inches is filled to a depth of 10 inches, it will contain 18.7 gal, or 155.8 lb, of water. The following simple calculation will give the total outward pressure against the four sides. The average depth is 5 inches, so each square inch of the sides is, on the average, under the pressure of a column of water 5 inches high. This column of water, 5 cubic inches, weighs 0.18 lb, because 1 gal, or 231 cubic inches, weighs 8.33 lb. The total area of the sides in contact with the water is 2 x 10 x 18 + 2 x 10 x 24 = 840 square inches; and 840 x 0.18 = 151.2 lb, the total outward pressure against the sides.

An aquarium of nearly the same dimensions as the one mentioned in the preceding paragraph was made with a frame of angle brass 3/4" wide. The mitered corners of the trim around the top were reinforced by soldering additional pieces of brass on the under side. After three or four years the steady pressure of the water broke the solder at one corner, and a bad leak started. This happened twice more, when it was decided that only riveting would make permanent repairs.

It would seem that an aquarium of the size stated is about as large a one as can be made safely with double-strength window glass. Experience has shown that the pressure is not great enough to burst the glass of an aquarium of that size. Careful tests would no doubt show that the pressure could be greatly exceeded before the glass broke, but this does not necessarily mean that double-strength window glass is safe to use in a larger aquarium. There should be a reasonable margin of safety. For this reason, single-strength window glass had better not be used in even a very small aquarium, because it is so easily broken by blows.

Changing the proportions of the aquarium, and especially the depth of the water, even though its volume remains the same, may make a serious difference in the pressure against the sides. For instance, a depth of 15 inches of water in an aquarium 16 by 18 inches will make 18.7 gal as before. But now the average depth is 7 1/2 inches, so the average pressure will be increased by one-half, or to 0.27 lb per square inch. The total area of the sides in contact with the water will be 2 x 15 x 16 + 2 x 15 x 18 = 1020, instead of 840, square inches. Then, 1020 x 0.27 = 275.4 lb, the outward pressure. It would not seem safe to expect anything but plate glass to withstand this pressure. Fortunately for the good of its inhabitants, an aquarium should be broad and shallow, and not narrow and deep. It is a good rule to have the depth of water no greater than the width of the aquarium. If the depth is much less, down to a reasonable minimum, so much the better.

Carefully measure the frame for the glass, and cut the latter as exactly as possible. It is best to make the measurements at the bottom of the frame, because the upright pieces at the corners may not all be vertical and parallel to one another. Especially if the frame is homemade, it is safest not to assume that opposite spaces are of the same length within, say, 1/16 inch.

Two pieces of glass, for opposite sides, can be practically the full length of the spaces into which they are to go, or perhaps better, about 1/16 inch shorter. The second pair of panes must be shorter than the corresponding spaces by the combined thicknesses of the first two with their layers of cement. If the bottom of the aquarium is to be covered with a piece of glass, decide when measuring whether it will be put into place before or after the sides. The dimensions of the bottom pane and the width of the side panes depend upon this decision.

An example will make the preceding paragraph clearer. Suppose the aquarium frame measures 15 by 18 inches inside, and is 10 inches high. If the longer sides are to be glazed first, the pieces of glass must be only 17 15/16 inches long, to allow 1/16 inch for clearance. The panes for the 15-inch spaces should be only 14 1/2 inches in length, if the glass is double-strength, which is a full eighth of an inch thick, or even a trifle more. In addition to the combined thicknesses of the two long panes there will be two layers of cement, each not more than 1/8 inch thick, in all totaling 1/2 inch, which leaves only the 14 1/2 inches of space mentioned.

If the bottom pane is to be put in place before the sides, it should measure 1/16 inch less than the space, or 14 15/16 by 17 15/16 inches. The sides will rest upon the bottom pane and the layer of cement under it. They should be only 9 3/4 inches wide, so they will not project above the top of the frame. If the bottom piece of glass is to be put in last of all, it must measure not more than 14 1/2 by 17 1/2 inches, or perhaps 1/16 less each way, for a reason that will appear later. The side panes, which will rest directly upon the bottom, can be a full 10 inches in width.

The allowances stated in the example will have to be changed if the glass differs much from 1/8 inch in thickness. If the job happens to be the glazing of a frame with grooves into which the glass slides, the measurements must be made accordingly. It may be safe to assume that the spaces are the same top and bottom, but if there is any doubt, an accurate measurement can be made at the bottom, with the aid of two strips of wood that when placed end to end are a few inches longer than the side to be measured. One end of each stick must be small enough to reach all the way into a groove. Hold the sticks in such a way that one end of each is in a groove, while the other ends overlap. On one of the sticks mark where the end of the other stick comes. Now lay them on a table in the same relative positions and accurately measure the distance from end to end. Cut the glass about 1/16 inch less than the total length just measured.

Sometimes, for one reason or other, a piece of glass will be a shade too long for the space. The excess is too small to be cut off, but it can be removed by means of a coarse file. Lay the glass on a table, with its edge projecting a fraction of an inch. Then with cautious downward strokes, with the file held at an angle of about 45 degrees with the glass, bevel the edge of the latter. Turn the glass over and repeat the process, and finally square the edge with the file held vertically. The chief risk in this operation is not breaking the pane, but getting chips of glass in the eyes. Wear goggles, or shut the eyes at each stroke of the file, and keep children away. Another method, though more likely to break the glass, is to chip the edge with the help of one of the slots of a glass cutter.

Various mixtures of bituminous and tarry substances, known as "marine glue", are used for calking the seams of pontoons, and for other similar purposes, but are not commonly regarded as suitable for aquarium cement. They stay quite soft, and in hot weather have a decided tendency to run. The cement for an aquarium should have more body than marine glue, so that it will not flow when it is warm, nor be squeezed out by the steady pressure of the water. It is of course possible to make a bituminous cement having the necessary properties, but to write a formula for one presupposes

a full knowledge of the properties of all the materials that go into it. Those who wish to experiment with bituminous mixtures should bear in mind that some tarry materials contain highly poisonous org anic compounds that are soluble in water, and that might injure the fish in the aquarium.

In this connection it may be said that although the cements recommended further on contain compounds of lead, a metal that is a cumulative poison, in actual use the cements prove to be harmless. The oil or varnish used in making them protects the lead compounds from the dissolving action of the water.

The cement must not be too soft, and if it does not finally set stone-hard, so much the better. These requirements are met well enough by the cements for which formulas are given further on. Each of them contains boiled linseed oil or varnish. In thin films on glass or metal, both the oil and the varnish should dry completely in a short time. The drying is caused by chemical combination with oxygen from the air, and though the first action is on the surface of the film, the inner parts also soon become oxidized. The cement in an aquarium is in a thick layer, measuring inwards from the exposed edge, so it takes a very long time for atmospheric oxygen to diffuse all through it and to harden it.

Cements that are said to remain soft indefinitely can be bought. The Bureau has examined none of them, and can express no opinion about them. The flexible cements used for calking the joints of masonry are mentioned for those who wish to experiment. To keep the cement from being forced out by the pressure of the water, it should have fine sand mixed with it. These cements are said to be made of whiting and other pigments, with blown rapeseed oil and possibly a little linseed oil.

The reason why the cement should remain more or less yielding is that glass and metals do not expand or contract at the same rate when the temperature changes. However, the degree of softness needed is perhaps exaggerated in the minds of those who know the bare fact of the expansion, but have no idea of its magnitude. Take the extreme case of an aquarium with an aluminum frame, and suppose it to be warmed from 70° to 100°F. For this 30° rise in temperature, each inch of the frame measured at the lower temperature will expand to 1.00039 inches and each inch of the glass will expand to 1.00015 inches. The difference, 0.00024 inch, is the amount the cement must yield. This amount is about equal to one-sixth the thickness of an ordinary sheet of cellophane. If the aquarium frame is brass or iron, the corresponding difference is still less than for aluminum. It does not matter whether the aquarium is 10 inches or 10 feet in length, because the expansion takes place equally over every running inch of a cemented joint.

In this discussion it has been assumed that the rise in temperature is brought about by a warming up of the room in which the aquarium is. The argument applies equally well if the temperature drops.

The Bureau of Fisheries has for a long time used an aquarium cement made by mixing 5 parts by weight of glazier's putty with 1 part each of powdered litharge and red lead, and enough boiled linseed oil to give the mixture the consistency of putty. The litharge, and especially the red lead, hasten the setting of the cement, but even so it is advisable to add a few drops of japan drier to the boiled oil. If slate-colored cement is desired, add a little lampblack. This is most easily done by mixing it with the dry powders, but in that case it is hard to tell just how much will be needed to give the cement the desired color. The mixed dry fillers are of a lighter color than the finished cement. The materials for this and the other cements can be bought in paint stores.

The National Bureau of Standards is not officially concerned with aquaria, though cements fall within its province. However, members of its staff constructed aquaria at home, and some of them have used a cement for which the formula is given in various books. In this formula all parts are by bulk, not by weight, as follows: Mix 10 parts each of plaster of paris, fine sand and litharge, 1 part of powdered rosin, and enough boiled linseed oil to make a stiff putty. If possible, the sand should be so fine that all of it will pass through a No. 60 sieve. Coarse sand will make a gritty cement that is hard to work. Powdered pumice can be used if really fine sand can not be obtained.

A variant of this formula is perhaps an improvement upon the original. The plaster is omitted, red lead replaces about 1/3 of the litharge, and spar varnish is used instead of boiled linseed oil. This cement is tackier than the one made with linseed oil, and for that reason is harder to work with.

None of the formulas need to be slavishly followed, provided the ingredients are thoroughly mixed and the resulting putty is neither so stiff that it can not be applied smoothly with a putty-knife, nor so soft that it will tend to flow, and will also take too many days to set.

The Bureau has been asked how to make aquarium cement of different colors. Those who are sufficiently interested may experiment with the formula of the Bureau of Fisheries, replacing part of the litharge and all of the red lead by paint pigments of the desired colors.

The cement can be made most easily on a piece of sheet metal or a pane of glass. Mix the dry materials thoroughly, then add the oil, or varnish, a little at a time, and work in each portion with a putty-knife. At one stage the mixture will seem hopelessly lumpy, but this is a sign that the end is approaching, and that only a little more oil will be needed. The portions added should be smaller than before and the working more thorough, because kneading makes the mass softer, up to a certain point. If the mark is overstepped, a little more of the dry materials must be added. If putty is used in the cement, spread it out in a thin layer, place the dry materials upon it, and proceed in the way just described.

It is not possible to calculate closely what weight of the dry ingredients will be needed to make enough cement for an aquarium of a given size, because the "bulking value", or volume occupied by a given weight of a powder, depends not only upon the actual density of the individual particles, but also upon their size and upon how closely they are packed together. Ordinarily the air spaces in a tightly packed mass of a fine powder total a greater volume than that of the solid particles. Another thing to remember is that when a fine and a coarse powder are mixed, say one cubic inch of each, there will be less than two cubic inches of the mixture, because the fine particles enter the larger spaces between the coarse particles. The oil or varnish used in the cement not only fills the air spaces, but it also coats the particles and keeps them from actually touching.

One must be content with making a rough estimate of the volume of cement that will be needed. If the frame has a base 18 by 24 inches, and the vertical angle-pieces are 12 inches high, there will be 8 x 12 + 2 x 18 + 2 x 24 = 180 running inches of metal to be cemented for the sides. If the glass overlaps the metal 1/2 inch, this will mean 1/2 x 180 = 90 square inches to be covered. Finally, if the layer of cement is 1/8 inch thick, there will be required 1/8 x 90 = 11.2 cubic inches of cement. A pane of glass on the bottom means an additional 84 running inches, or 5.2 cubic inches of cement. The total, 14.6 cubic inches, is about 0.5 pint, liquid measure. It would not be wise to figure as closely as this in buying the materials or in mixing the cement. The ingredients are so cheap that one can afford to make considerably more cement as a margin of safety in case of mistakes.

Before starting to put in the glass, it is advisable to make ready several slender strips of wood, to hold the panes under gentle pressure against the cement. They should be a little longer than the distance between opposite panes, so that they must be bent slightly when set in place. They will thus exert a steady pressure that will keep the glass from falling inward. The pressure should not be so great as to force out any great amount of the cement. If this should occur, the strips of wood are too long and stiff, the cement is too soft, or too much of it has been applied.

Judgment must be exercised in preparing and using the wooden strips, so that they will do their work most safely and effectively. No fixed rule can be laid down for lengths and thicknesses that will be right for an aquarium of any particular size. At least four will be needed for each two pieces of glass, but if the panes are much over a foot in length it is advisable to use two or three more. Do not set any of the strips close to the corners, but 4 or 5 inches away, measured along the diagonals of the panes. If more than four are used, space all of them in such a way that the pressure will be as even as possible over the whole area. If a discarded inner tube is conveniently at hand, little squares cut from it are useful to keep the ends of the sticks from slipping on the glass.

With a putty-knife apply a smooth, thin layer of cement to the parts of the metal frame against which the two full-size panes are to go. Set these panes in place and press them gently with outspread fingers so as to make perfect contact between glass and cement. There should be no large air bubbles trapped in between, and especially no air channels that extend across the layer of cement. If the cement is carefully smoothed when applied and is made thinner towards the edge of the metal, the chance of trapping air will be lessened. If everything looks satisfactory, hold the panes in place by means of wooden strips. Next, cement the rest of the frame, insert the last two pieces of glass and hold them with strips.

Unless the bottom of the aquarium is made of slate, it is desirable to cover it with a pane of glass, which can be inserted either before or after the sides are in place. If after, a piece of stiff wire bent at a right angle at the end can be used as a hook to let it down gently, because the clearance will be too small for the fingers. In either case the pane on the bottom must be cemented, just as the sides are. It would be extremely difficult, if not impossible, to cement evenly the entire bottom of the metal frame, yet the glass should be supported in the middle, or the weight of water will bend, and may break, it. Fortunately it will suffice to place little dabs of cement here and there over the bottom of the aquarium. These, with the layer of cement around its edges, will support the glass a fraction of an inch above the metal bottom. In the 18 by 24-inch aquarium that has been mentioned, the bottom is of galvanized iron resting flat upon a table, and the glass that covers it is double-strength window glass. If there is no table nor a strong metal bottom, plate glass or a slab of slate should be used for an aquarium of that size.

If the glass for the bottom is the last piece to be inserted, the strips of wood must be removed temporarily, but they should be replaced promptly. Then clean off any excess of cement, smooth its exposed edges, and give the job a close inspection. Look especially for air channels, and if there are any, close them by working in cement with the putty-knife, and if possible, from the inside of the aquarium.

If everything seems to be right, leave the aquarium untouched for at least 24 hours. By that time the pressure of the sticks will probably have forced out a little cement from the joints. Remove this with the putty-knife, or with a scraper made of a small square of sheet metal. While doing this on the outside of the aquarium, be careful not to push too hard against the glass, lest the cement be loosened.

After another 24 hours, repeat the inspection. Little if any more cement should have been squeezed out, unless it was entirely too soft at the start, or the oil happens to be slow-drying. If the cement seems to be hard enough, clean the glass surfaces by scrubbing them gently with powdered pumice or a non-scratching cleaning powder, on a piece of wet rag. Remove all loose bits of cement.

By this time the average builder of an aquarium will find it difficult to resist the temptation to fill it with water. It will be safe to do so, as a rule. The sticks can now be removed. The filled aquarium should be left alone for another day or two to make sure that there are no slow leaks. If there are any large openings in the cement, water will come through them as soon as the aquarium is filled. In that case all the water must be taken out, and the aquarium be wiped dry inside and out. Then, after the crevice has had time to dry out, close it by working cement into it, from the inside of the aquarium. The cement for this purpose can be a little softer than that used at first, to make it go into the narrow space more easily.

There may be one or more tiny leaks through which the water slowly oozes. Indeed, it has been said that a new aquarium always leaks a little. It is usually possible to stop such leaks without taking out the water. Get a little of the stiffest clay that can be found (for instance, "ball clay"), moisten it and work it in the hands. Then apply a little of it over each leak, on the inside of the aquarium. It will be washed away gradually, but enough of it will be left to fill the holes and stop the leaks. The same treatment can be given to leaks that sometimes start after the aquarium has been in use for months.

It is recommended, though the advice is not based upon the results of experiments, not to put plants and fish in the first water with which the aquarium is filled. At least it has the best chances of all to become contaminated with lead.

The Bureau of Fisheries, Department of Commerce, Washington, D.C., should be applied to for information about fish and aquatic plants, and the maintenance of the aquarium. Those who live near large public libraries can find various books and magazines on aquarium fishes. Among the authors of books whose names will be in the library catalog are W. L. Brind, O. Eggeling and F. Ehrenberg, E. M. Goldberg, W. T. Innes, I. M. Mellon, H. Mulertt, C. N. Page, T. C. Roughly, M. Samuel, Eugene Smith, Hugh M. Smith, F. H. Stoye, C. H. Townsend, and H. T. Wolf. It is not necessary to give the titles of their books.

A simple device for aerating an aquarium is described in Science, vol. 77, pp. 565-6, June 9, 1933. It can be used where running water and a drain-pipe are not available. Other aerating devices, run by electric motors, are on the market. Electric heaters, most of them with temperature control (thermostats), as well as cements and other materials for making aquaria, can be bought. Numerous advertisements are to be found in the magazines.